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sigrok:

Adventures in Integrating a Power-Measurement Device

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ACME overview:

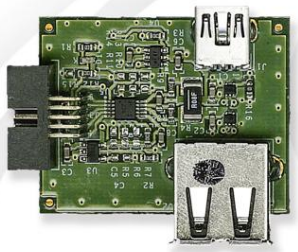
(*Another Cute Measurement Equipment*)

Objectives, key features & status

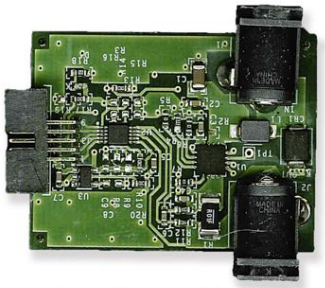
Problem statement

- Power Management optimization is the key for power-hungry battery-operated devices,
- Limited power measurement equipment,
  - *Expensive high-precision lab equipment,*
  - *Existing low-cost solutions but with limited performances (i.e. accuracy),*
  - *No standard power measurement connector,*
- The community needed a high-perf low-cost standard solution for power measurements.

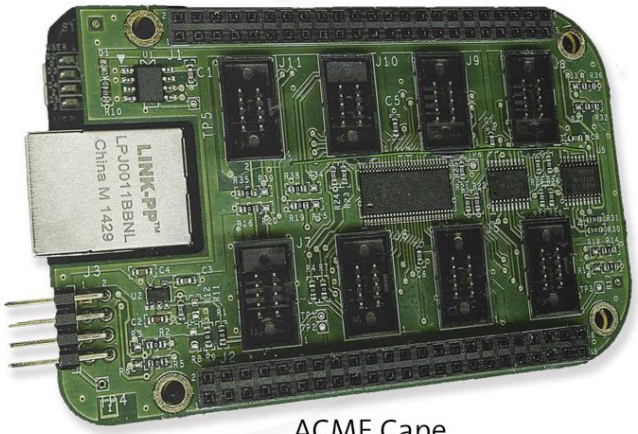
The answer: ACME Cape



USB Power Probe

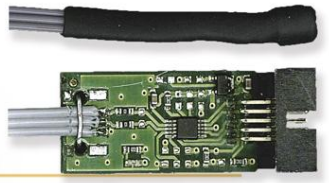


Jack Power Probe



ACME Cape

ACME Power Probe



Temperature Probe

ACME Cape: key features

- **Multi-channel:**
  - 8, up to 16 with Cape stacking.
- **All-in-one solution for power measurement, power control, and temperature measurement.**
- **Flexible / Evolutive:**
  - Extension connector for use with other HW than BBB,
  - New probes can be designed, w/o HW change required on ACME cape.

ACME Cape: key features

- Low-cost,
- Uses TI INA226 & TMP435 components supported by upstream Linux drivers,
- Defines a standard low-cost power measurement connector and provides power probes following this standard,
- Version 2 – USB dongle.

Problem: software support

- **Writing our own software-suite**
  - costs of development and maintenance
  - duplicating functionalities
  - duplicating bugs
  - clients don't like learning new programs
- **Contributing to a well-known and supported project**
  - help from the community
  - existing code base and documentation
  - brand appealing to users

Problem: software support

- ACME is open hardware,
- ACME needs a complete open-source software suite,
- Sigrok supports power measurement devices,
- Let's contribute to sigrok!

sigrok overview:

portable, cross-platform, Free/Libre/Open-Source signal analysis software suite

Design goals and features

sigrok: key features

- flexible,
- cross-platform,
- hardware-independent,
- supports various device types,
- modular architecture.

Broad hardware support

- **129 supported devices**
- **20 in progress**
- **Initially developed for logic analyzers**
- **Now supports various device types:** logic analyzers, oscilloscopes, multimeters, energy meters, sound level meters, thermo-, anemo- and hygrometers, dataloggers & many, many more.

Broad hardware support

Cross-platform

- **Works on:** Linux, Mac OS X, Windows, FreeBSD, OpenBSD, NetBSD, Android.
- **Now available in Buildroot (BayLibre contribution).**

Flexible input/output

- **Supports various file formats:**
  - binary, analog, ASCII, hex, CSV, gnuplot, VCD, WAV, ChronoVu LA8, OLS.
- **Transformation modules (work in progress):**
  - **Allows transformation of data between the source and output:** nop, scale, invert, average, adc/dac (analog to/from digital conversion).
- **collectd plugin available**

Various frontends

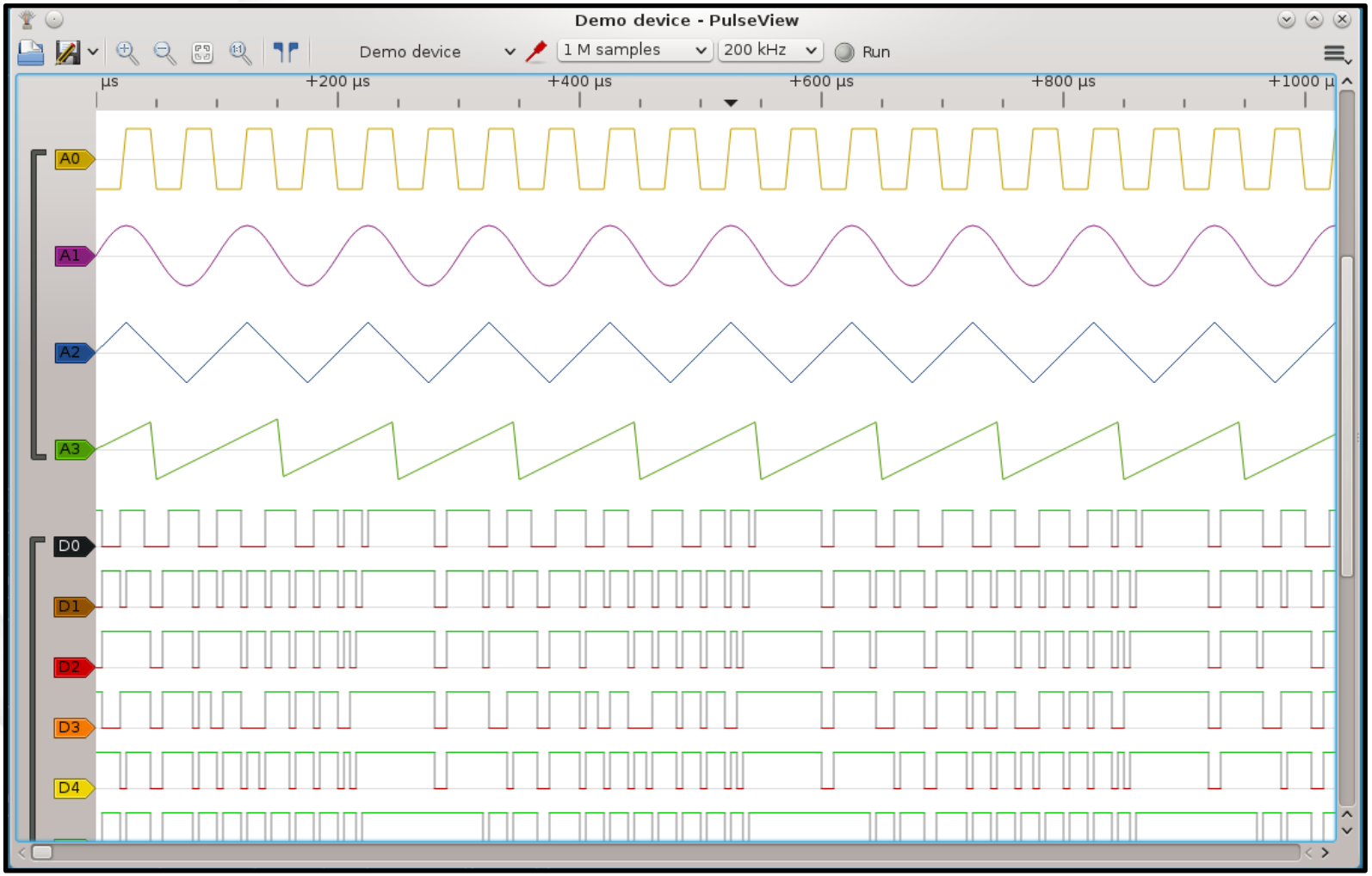
- Command-line: sigrok-cli
- GUI: PulseView
  - Aimed mainly at logic analyzers,
  - Channel grouping support
  - Qt based,
  - Fast O(log N) signal rendering at all zoom levels.
- sigrok-meter (work-in-progress):
  - Written in Python (2 & 3) + PyQt/PySide,
  - Uses Python bindings generated by SWIG,
  - Aimed at multimeters and dataloggers.

Various frontends – sigrok-cli

Examples:

- sigrok-cli --scan
- sigrok-cli --driver=baylibre-acme --show
- sigrok-cli --driver=baylibre-acme --get probe_factor --channel-group=Probe_1
- sigrok-cli --driver=baylibre-acme --config probe_factor=80 --set --channel-group=Probe_1
- sigrok-cli --driver=baylibre-acme --samples=50 --config samplerate=100
- sigrok-cli --driver=baylibre-acme --time=10s --output-format=analog
- sigrok-cli --driver=baylibre-acme --continuous --transform-module=scale:factor=3.14

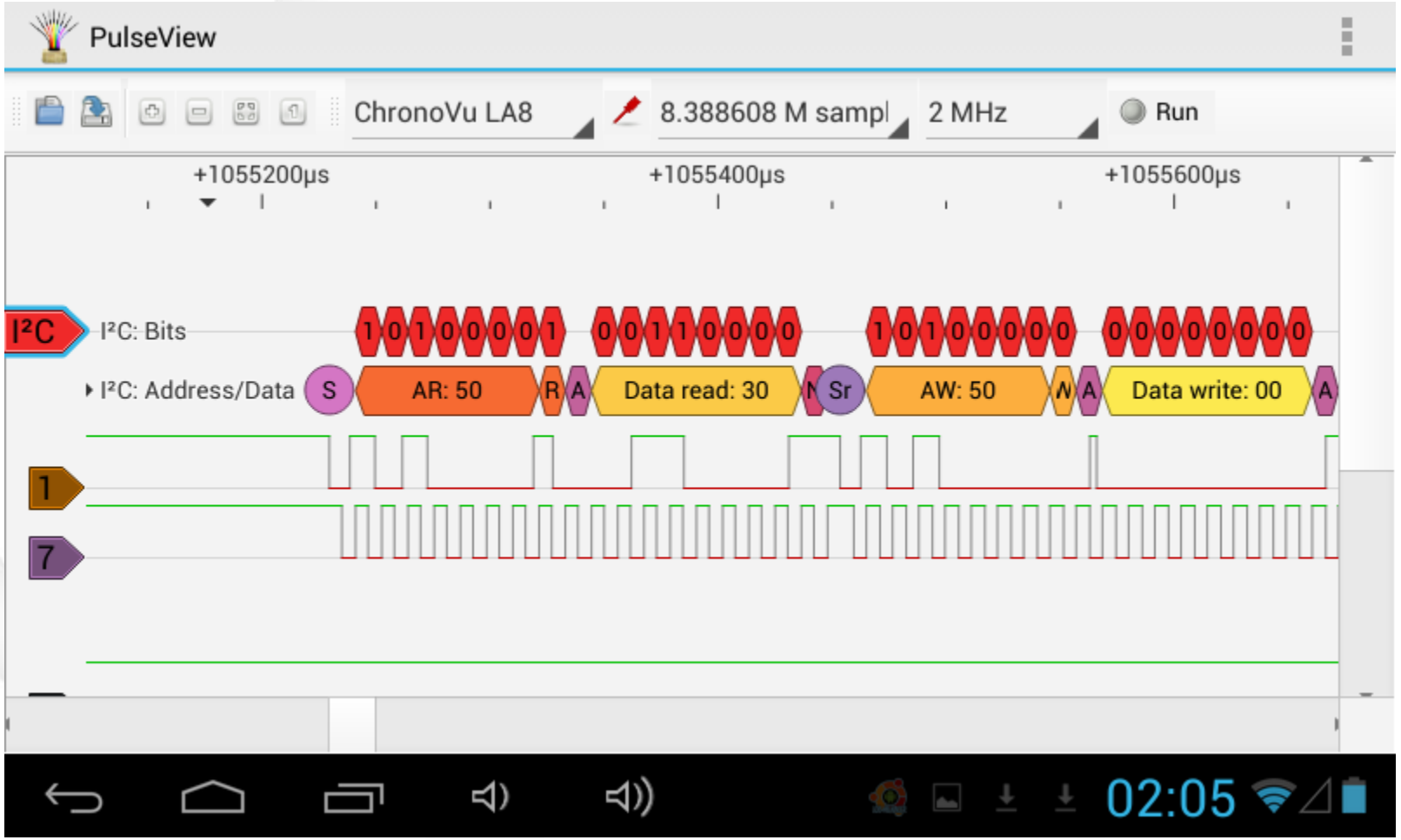
Various frontends – PulseView



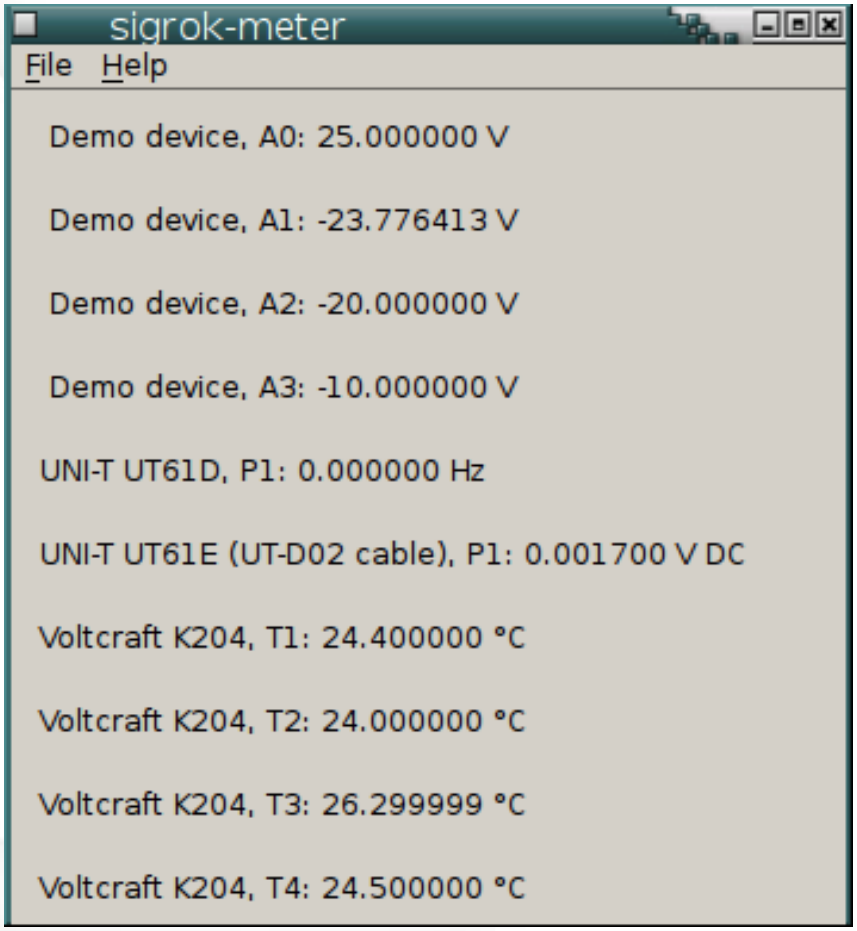
Various frontends – PulseView

- **Android port:**
  - Not written from scratch,
  - Portable C++11 + minimal Android ‘glue’,
  - Reuses libsigrok and libsigrokdecode together with all the functionalities (protocol decoders!).

Various frontends – PulseView



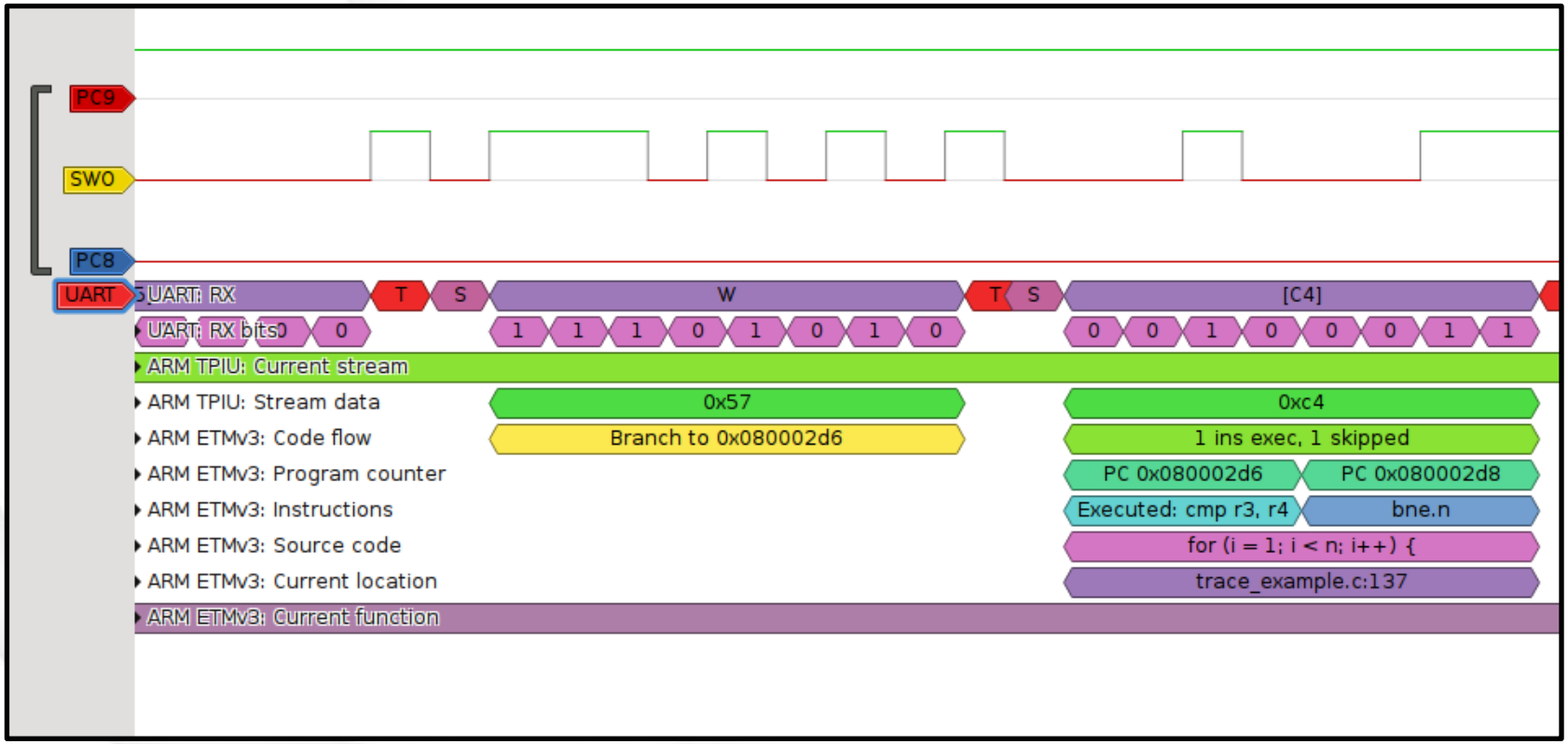
Various frontends – sigrok-meter



Protocol decoders

- Way to easily visualize data captured by logic analyzers,
- Written in Python3,
- Stackable,
- Even allow to decode ARM CPU instructions and associate them with code snippets!

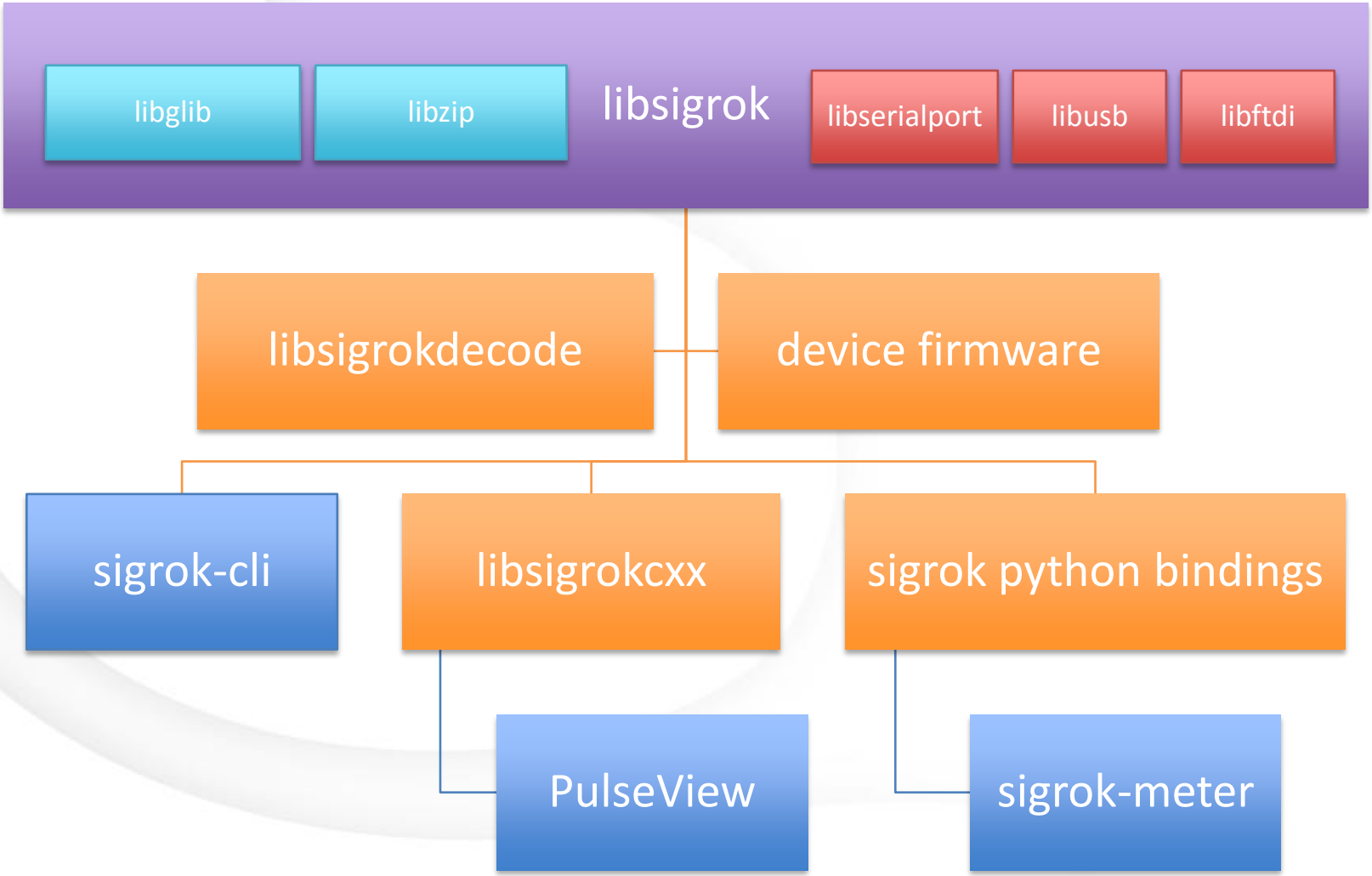
Protocol decoders



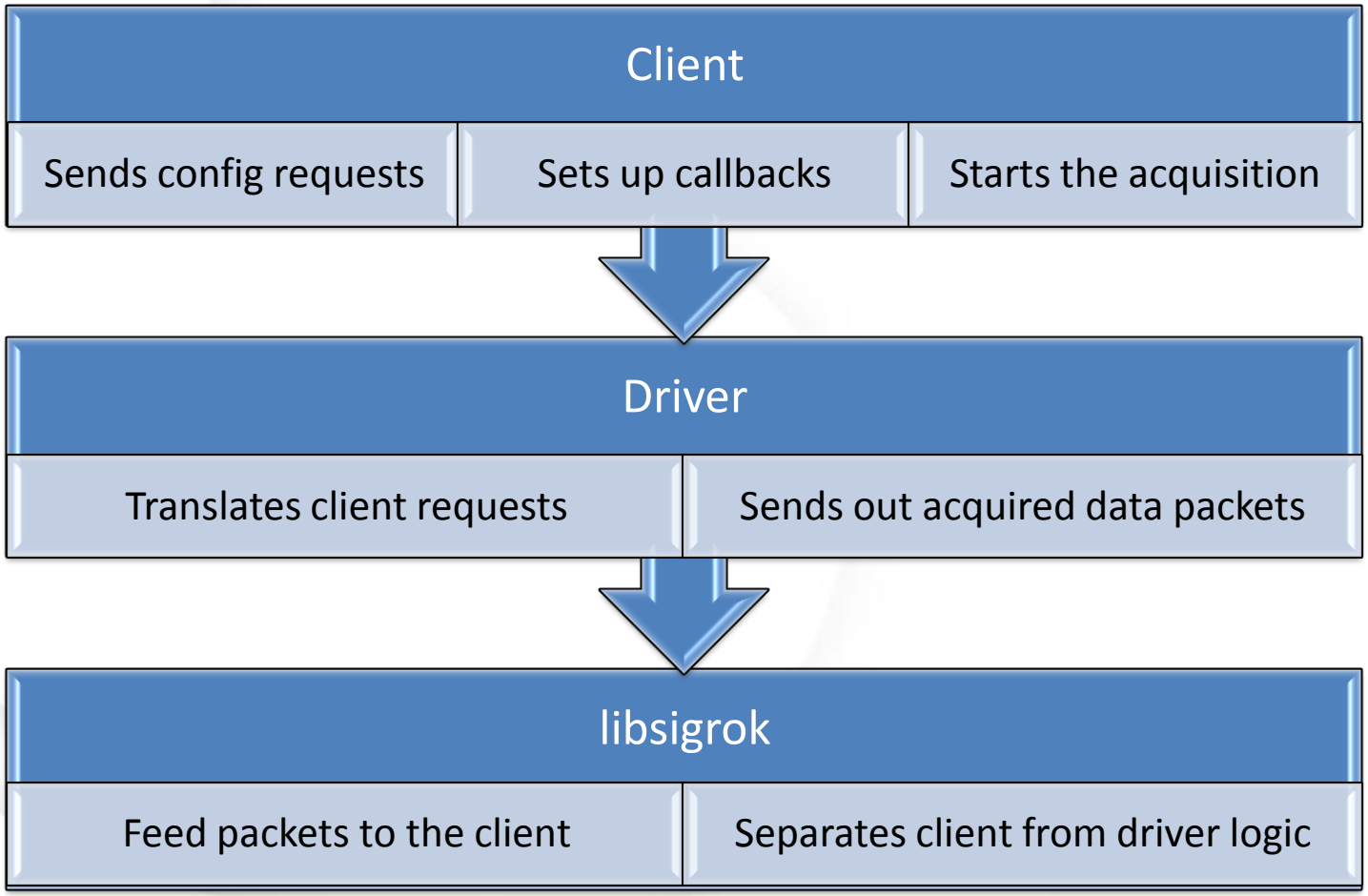
sigrok architecture

- **Reusable libraries:**
  - libsigrok, libsigrokdecode.
- **Configurable compilation:**
  - libftdi, libserialport, libusb, libsigrokdecode.
- **Bindings:**
  - C++, Python, Java.
- **Modular drivers.**

sigrok architecture



sigrok flow


Client
Sends config requests
Sets up callbacks
Starts the acquisition
Driver
Translates client requests
Sends out acquired data packets
libsigrok
Feed packets to the client
Separates client from driver logic

sigrok:
supporting new hardware

Implementing new libsigrok drivers - tutorial based on ACME

sigrok: supporting new hardware

- **sigrok-util/source/new-driver**
  - updates Makefile.am and configure.ac,
  - adds driver struct to global driver list in src/drivers.c.
- **Implementation split into:**
  - api.c,
  - protocol.h,
  - protocol.c.
- **Goal:**
  - implement device specific callbacks and let the sigrok framework handle the rest.

sigrok: supporting new hardware

Callback based driver:

```
SR_PRIV struct sr_dev_driver baylibre_acme_driver_info = {
	.name = "baylibre-acme",
	.longname = "BayLibre ACME (Another Cute Measurement Equipment)",
	.api_version = 1,
	.init = init,
	.cleanup = cleanup,
	.scan = scan,
	.dev_list = dev_list,
	.dev_clear = dev_clear,
	.config_get = config_get,
	.config_set = config_set,
	.config_list = config_list,
	.dev_open = dev_open,
	.dev_close = dev_close,
	.dev_acquisition_start = dev_acquisition_start,
	.dev_acquisition_stop = dev_acquisition_stop,
	.priv = NULL,
};
```

sigrok: supporting new hardware

Device instance

```
struct sr_dev_inst {
    struct sr_dev_driver *driver;
    int status;
    int inst_type;
    char *vendor;
    char *model;
    char *version;
    char *serial_num;
    char *connection_id;
    GSList *channels;
    GSList *channel_groups;
    void *conn;
    void *priv;
    struct sr_session *session;
};
```

sigrok: supporting new hardware

```
int (*init)(struct sr_context *sr_ctx);
int (*cleanup)(void);
```

Called after the driver is loaded or before it's unloaded.

Helpers available – std_init(), std_dev_clear() etc.

Very basic init function:

```
static int init(struct sr_context *sr_ctx)
{
    return std_init(sr_ctx, di, LOG_PREFIX);
}
```

sigrok: supporting new hardware

```
GSList *(*scan)(GSList *options);
```

- Initialize and scan for devices.
- Driver should do all the initialization required.
- Return NULL if no device found or the list of struct sr_dev_inst.

sigrok: supporting new hardware

```
GSList *(*dev_list)(void);
int (*dev_clear)(void);
```

- Get & clear the list of device instances the driver knows about,
- Usually just:

```
static GSList *dev_list(void)
{
   return ((struct drv_context *)(di->priv))->instances;
}
```

sigrok: supporting new hardware

```
int (*config_get)(uint32_t key, GVariant **data,
          const struct sr_dev_inst *sdi,
          const struct sr_channel_group *cg);
int (*config_set)(uint32_t key, GVariant *data,
          const struct sr_dev_inst *sdi,
          const struct sr_channel_group *cg);
int (*config_list)(uint32_t key, GVariant **data,
          const struct sr_dev_inst *sdi,
          const struct sr_channel_group *cg);
```

Get/set configuration options & list all available values for given option.

sigrok: supporting new hardware

- Options listed in sr_configkey in libsigrok.h.
- Defined in src/hwdriver.c.
- Reuseable options e.g. ACME shunt resistance -> probe_factor.
- Well-known data types allow for options to be easily understood by GUIs.

sigrok: supporting new hardware

General device options and per-channel-group options, e.g.:

```
static const uint32_t devopts[] = {
    SR_CONF_CONTINUOUS | SR_CONF_SET,
    SR_CONF_LIMIT_SAMPLES | SR_CONF_GET | SR_CONF_SET,
    SR_CONF_LIMIT_MSEC | SR_CONF_GET | SR_CONF_SET,
    SR_CONF_SAMPLERATE | SR_CONF_GET | SR_CONF_SET | SR_CONF_LIST,
};

static const uint32_t devopts_cg[] = {
    SR_CONF_PROBE_FACTOR | SR_CONF_GET | SR_CONF_SET,
    SR_CONF_POWER_OFF | SR_CONF_GET | SR_CONF_SET,
};
```

sigrok: supporting new hardware

```
int (*dev_open)(struct sr_dev_inst *sdi);
int (*dev_close)(struct sr_dev_inst *sdi);
```

Device specific callbacks called before and after starting data acquisition, setting a config option etc.

Several boilerplate reducing helpers available for USB and serial devices:
std_serial_dev_open() etc.

sigrok: supporting new hardware

```
int (*dev_acquisition_start) (const struct sr_dev_inst *sdi,
                              void *cb_data);
int (*dev_acquisition_stop) (struct sr_dev_inst *sdi,
                             void *cb_data);
```

- Start/stop data acquisition
- Setup callbacks and polling machinery
- *_source_add_* & *_source_remove_* functions

sigrok: supporting new hardware

From agilent-dmm/api.c:

```
static int dev_acquisition_start(const struct sr_dev_inst *sdi, void *cb_data)
{
        (...)

        /* Send header packet to the session bus. */
        std_session_send_df_header(cb_data, LOG_PREFIX);

        /* Poll every 100ms, or whenever some data comes in. */
        serial = sdi->conn;
        serial_source_add(sdi->session, serial, G_IO_IN, 100,
                        agdmm_receive_data, (void *)sdi);

        return SR_OK;
}
```

sigrok: supporting new hardware

- **Existing frameworks:**
  - USB,
    - USBTMC,
  - Serial,
  - SCPI,
    - VXI-11,
  - gpio (introduced by ACME).
- **Most devices have USB or serial connectivity:**
- **Unusual drivers:**
  - ACME,
  - BeagleLogic.

Pitfalls

- Per probe config options,
  - Using --channel-group parameter to set options for a single probe (tried using key-value arguments).
- Proper callback setup in dev_acquisition_start.

Upstreaming effort

- ACME driver for libsigrok, a couple of new features & several bug-fixes merged upstream by BayLibre:
  - Responsive maintainers,
  - Help available on IRC:
    - Fixed an interesting bug in Doxyfile preventing from building libsigrokcxx via buildroot together.
- sigrok packages available in Buildroot.
- Several extensions and bug-fixes for ina2xx and tmp401 drivers in Linux.

ACME & sigrok demo

ACME & sigrok technical showcase today at 6:30 pm

Q & A

Resources:

http://sigrok.org/
http://baylibre.com/acme/
http://wiki.baylibre.com/doku.php?id=acme:start
http://sigrok.org/wiki/BayLibre_ACME

Thank You!